Michigan Tech

Office Memo

Office of the Provost and
Senior Vice President for Academic Affairs

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TO: Richard Koubek, President

FROM: Jacqueline E. Huntoon, Provost & Senior Vice President for Academic Affairs Jacqueline E Huntoon

DATE: April 22, 2021

SUBJECT: Senate Proposal 71-21

Attached is Senate proposal 71-21, “Establishment of a New Graduate Certificate in Manufacturing Engineering,” and a memo stating the Senate passed this proposal at their April 21, 2021 meeting. I have reviewed this memo and recommend approving this proposal.

I concur X do not concur_____ with this recommendation.

Richard Koubek, President

4/26/21

Date

Michigan Tech

University Senate

DATE:	April 22, 2021
TO:	Richard Koubek, President
FROM:	Samuel Sweitz University Senate President
SUBJECT:	Proposal 71-21
COPIES:	Jacqueline E. Huntoon, Provost & Senior VP for Academic Affairs

At its meeting on April 21, 2021, the University Senate approved Proposal 71-21, "Establishment of a New Graduate Certificate in Manufacturing Engineering". Feel free to contact me if you have any questions.

The University Senate of Michigan Technological University

Proposal 71-21

Establishment of a New Graduate Certificate in Manufacturing Engineering

Submitted by: MMET Department, College of Engineering

1. **Proposal Date:** February, 2021
2. **Proposing Contacts and Departments:** John L. Irwin, Professor/Chair, MMET department, jlirwin@mtu.edu

   MMET Manufacturing Degree Taskforce Members:
   Scott Wagner, Associate Professor, MMET, sawagner@mtu.edu
   David Labyak, Assistant Professor, MMET, dmlabyak@mtu.edu
   David Wanless, Senior Lecturer, MMET, ddwanles@mtu.edu
   Nicholas Hendrickson, Adjunct Instructor, MMET, nphendri@mtu.edu

3. **Sponsor Department Approvals**: approved

4. **General Description and Characteristics of Certificate:** This certificate is designed for the working professional to align course projects to applications in their place of work. Courses will be offered entirely online to suit learners in the workplace. Application-based course activities will be performed at an employee's workplace. This nine-credit certificate can be combined with additional certificates or used on its own as a stepping stone to advance one's career in manufacturing.

   4.1. This graduate certificate encompasses the building blocks of advanced manufacturing, which crosscut the Manufacturing Engineering Building Blocks (Figure 1).

   Certificate Learning Objectives: Upon successful completion of this certificate, students will be able to do the following:

   4.1.1. Manage and/or provide leadership for teams to successfully implement manufacturing processes. (**Manufacturing Competitiveness** Building Block)
   4.1.2. Communicate effectively utilizing the fundamental concepts of Geometric Dimensioning and Tolerances (GD&T) necessary in the manufacturing sector. (**Product Tooling and Assembly Engineering** Building Block)

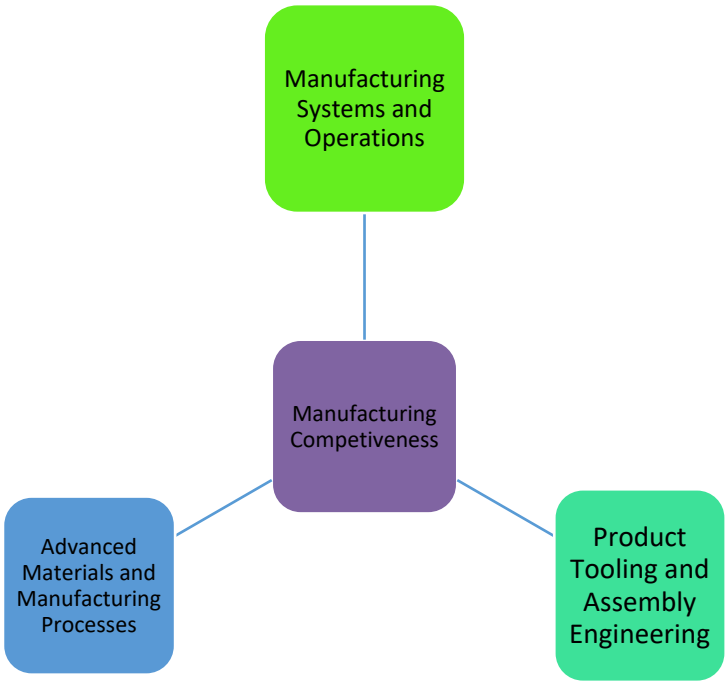

Figure 1. Manufacturing Engineering Building Blocks

4.2. This certificate will prepare a new manufacturing engineer for management of larger systems. The courses in this certificate include leadership, teamwork skills, industry 4.0 concepts, design for additive manufacturing, and advanced geometric dimensioning and tolerance techniques.

5. Rationale for the Certificate:

This certificate aligns with the needs identified by the Michigan Tech Advanced Materials and Manufacturing Tech Forward Initiative. This proposal concept has been presented to this group and was received positively with support from faculty representation from various departments on campus.

The need for manufacturing engineers and engineering managers is evident from recent studies regionally from Wisconsin and Michigan as well as nationwide. The NEW (Northeast Wisconsin) Manufacturing Alliance Needs, Skills, & Talent Survey was conducted in 2019 tallying responses from over 100 manufacturers. One primary outcome from this report is that curriculum and training programs that develop process engineers and data analysts are in high demand.

Automation Alley is Michigan's Industry 4.0 knowledge center. Their mission is to help manufacturers of all sizes understand the rapid technological changes associated with digitalization so that Michigan and the nation remains globally competitive. In the Automation Alley 2019 Industry 4.0: From Vision to Implementation report a positive rate of change in the areas of additive manufacturing and advanced materials is shown in following four technology markets: 1) Automotive, 2) Medical 3) Retail, and 4) Energy. Additive

manufacturing (3D printing) is a process that creates three dimensional objects by depositing layers of materials, which is an integral part of Industry 4.0 technologies. The National Science and Technology Council, 2018 report "Strategy for American Leadership in Advanced Manufacturing," identifies the developing and transitioning new manufacturing technologies including smart manufacturing as a core component. To achieve this, small and medium manufacturers must have the knowledge to upgrade their operations. An example of the smart manufacturing technologies referred to in this study includes additive manufacturing.

Nationwide interest in manufacturing fields of study according to a 2016 Survey conducted by Opinion Research Corporation, indicates that 37 percent of millennials perceive manufacturing as a high technology career choice, notably higher than both Generation X (27 percent) and Baby Boomers (23 percent). The study also reveals that more millennials (49 percent) believe engineering is a needed skill in manufacturing and forty percent of millennials also recognize that manufacturing careers are high paying. These findings are a good indication for the ability to recruit young people into manufacturing engineering careers.

6. **Related Programs**:
Within all the graduate degrees that fall under the manufacturing engineering discipline, the prerequisites are fairly common. The programs are primarily intended for individuals who possess a baccalaureate degree with a major in a technical field such as engineering or technology, possess a grade point average of 3.0 or higher, have completed undergraduate courses or have work experience in Computer Aided Design, Computer Aided Manufacturing, Quality Control, Statics, and Strength of Materials. The Graduate Record Exam (GRE) is not required in all instances. The majority of universities offer these graduate programs by accommodating the work requirements of full-time professionals with courses offered in the evenings and weekends, or by distance learning means.

The MMET department has a minor in Manufacturing Systems that is popular with MET undergraduate students that already has a focus in manufacturing through their technical elective courses. This certificate is also related to the minor in Manufacturing that is offered through the ME-EM department that also prepares students in economic decision analysis and an introduction to manufacturing with electives in areas of manufacturing processes, lean, production planning, and other manufacturing fundamentals. Finally, the BSE in Systems Engineering in the Engineering Fundamentals department also has a minor that requires 14 credits of courses in systems modeling, project management, and sustainability with 6 credits of electives for students to choose from courses in lean, supply chain management, or six sigma. This graduate certificate will build on these manufacturing fundamentals such as lean, six sigma, production planning, systems modeling, and automated control system design.

There are several universities that are offering Additive Manufacturing (AM) certificate programs. Due to the popularity of Industry 4.0 technologies, some AM certificates are stand-alone not associated with a MS degree. One such certificate program offered through Purdue linked here, is aimed at either engineers and managers or business professionals developed as 4 courses (2 Core + 2 Electives). The two core courses are "AM Essentials" and "AM Technology & Materials", with electives offered as "AM Design" and "AM Business & Economics". The first three courses in this certificate are very similar to those proposed in this certificate, but the fourth course, AM Business & Economics is not applicable to the type of manufacturing engineering student we are targeting. Ohio State University has a Master of Global Engineering Leadership (MGEL) linked here, that has 16-18 Core credits and an Additive Manufacturing track where students can choose four courses from a list of five. The Ohio State University AM courses are similar to those in this proposal with the addition of a "Computational Modeling of Additive Manufacturing" and "Science and Engineering Foundations of Additive Manufacturing" which both have an emphasis in design aspects like heat transfer and engineering mechanics.

Additional benchmarking of manufacturing graduate certificates revealed that there are universities offering masters degrees that have areas of concentration or focus areas. One such example is Worchester Polytechnic Institute linked here, that has a Masters in Manufacturing Engineering with focus areas to choose from in Control Systems, Design, Financial Processes, Health Systems Engineering, Manufacturing and Materials Processes, Manufacturing Systems, Materials Engineering, and Statistics and Quality Assurance. This is an interdisciplinary degree requiring 12 credits from the College of Business and 15 credits from the College of Engineering with equal emphasis in both manufacturing engineering and manufacturing/operations management, but there are no individual certificates offered in the focus areas.

The University of Wisconsin Stout has an established online MS in Manufacturing Engineering linked here, that has a foundation set of 15 credits required in courses such as Six Sigma, Quality Improvement, Occupational Risk Control/Safety, Organizational Research Methods, and Manufacturing System Design and Simulation. Student can choose 6 credits from group1 and 9 credits from group2. The group1 category has courses in Financial and Cost Analysis, Program Management, Human Factors Engineering/Ergonomics, and Sustainable Engineering. The group2 category has courses such as Quality Engineering, Lean Enterprise, and Enterprise Resource Planning. This institution does not offer certificates in the foundation or the group1 or group2 offerings.

7. **Projected Enrollments**:
A survey was conducted by the MMET department to assess the interest in Manufacturing Engineering graduate courses by employers, as well as current MET students and alumni. Additional questions in the survey were to assess the most popular methods of delivery for the program. The survey was distributed by email to two groups; employers using the 10 individuals on the MMET department Industrial Advisory Board, current students and alumni

using the MMET student email group list and emails from 2019-20 MET graduates. The responses yielded a typical 20-30% return for the student and alumni, n=27. For the employer survey there is representation from companies such as Pettibone, Cummins, Greenheck, and Honda Manufacturing, n=6. The response to the first question, "Would you consider the opportunity to obtain a MS in Manufacturing Engineering requiring 30 credits after completing your MET degree?" was 23 (85%) yes. For employers the same question was answered 6 (100%) yes.

The marketing plan for the certificate in Manufacturing Engineering is to use social media to target current MET students early in their career to consider pursuing the degree and to advise students interested to take advantage of the Accelerated Master's program. Also, the Graduate School will be encouraged to actively market this certificate with international students as partial fulfillment of a graduate degree, especially those that have an interest in manufacturing over traditional product design research and development. MET alumni are the most likely group to target since they are familiar with the faculty and the facilities. The ability to complete projects as part of the degree requirements is favored by MET alumni. The vast majority 25 (93%) of the students answered "yes" to the question "Would you be interested in course lab assignments being satisfied by completing in-plant projects in the workplace?", and 100% of the employees also answered "yes".

The need for the certificate (which is a step towards a graduate degree) is reinforced by the 6 (100%) responses by employers that replied "yes" to the question "Would you consider hiring an applicant with a graduate degree in Manufacturing Engineering?" This is also reinforced with the Bureau of Labor Statistics (BLS) data indicating that Occupational Employment and Wages, May 2018 for 11-3051 "Industrial Production Managers." This role is defined by the BLS as "Plan, direct, or coordinate the work activities and resources necessary for manufacturing products in accordance with cost, quality, and quantity specifications." Michigan has the highest concentration of jobs with this title shown in Table 1. The Location Quotient (LQ) compares the concentration of an industry within a specific area to the concentration of that industry nationwide. An LQ greater than 1 indicates an industry with a greater share of the local area employment than is the case nationwide, which Michigan is the highest of the top 5 states. The employment estimate and mean wage estimates for this occupation are shown in Table 2. The Relative Standard Error (RSE) of the employment estimate is a measure of the reliability or precision of the employment estimate. The relative standard error is defined as the ratio of the standard error to the survey estimate. The reported annual wage for Industrial Production Managers of $113,370 is higher than the mean annual salary for MET majors of $99,310 as reported by National Occupational Employment and Wage Estimates, United States Department of Labor. This increased salary is an incentive for MET alumni to pursue this certificate and further their education.

Table 1. Top five States with the highest concentration of jobs and location quotients for Industrial Production Managers

State	Employment	Employment per thousand jobs	Location quotient	Hourly mean wage	Annual mean wage
Michigan	13,110	3.04	2.42	$57.10	$118,760
Wisconsin	6,580	2.31	1.84	$53.01	$110,250
Iowa	3,490	2.27	1.81	$47.14	$98,040
Ohio	11,380	2.10	1.68	$52.50	$109,190
Kentucky	3,800	2.01	1.60	$46.80	$97,340

Table 2. Nationwide employment estimate and mean wage estimates for Industrial Production Managers.

Employment	Employment RSE	Mean hourly wage	Mean annual wage	Wage RSE
181,310	0.7 %	$54.51	$113,370	0.3 %

8. **Scheduling Plans**:

Courses will be offered **fully online** during the fall and spring semesters. Students surveyed were rather split in how they would prefer to have courses offered, but the majority 21 (78%) preferred a traditional 14-week semester requiring three contact hours per week, as compared to weekends, or two-week intensives in the summer. The preferred mode of delivery for students was approximately split between the options of on-campus in person labs and labs offered on weekends or summer as shown in Figure 2. Employers preferred 4 out of 6 (67%) the option "c." offering in person labs on weekends or in the summer. Given these responses it was decided to not include courses with labs for the online certificate, although the courses will include application-based learning activities to be performed at the workplace. Group projects will accommodate students that are not currently in roles that accommodate a workplace project.

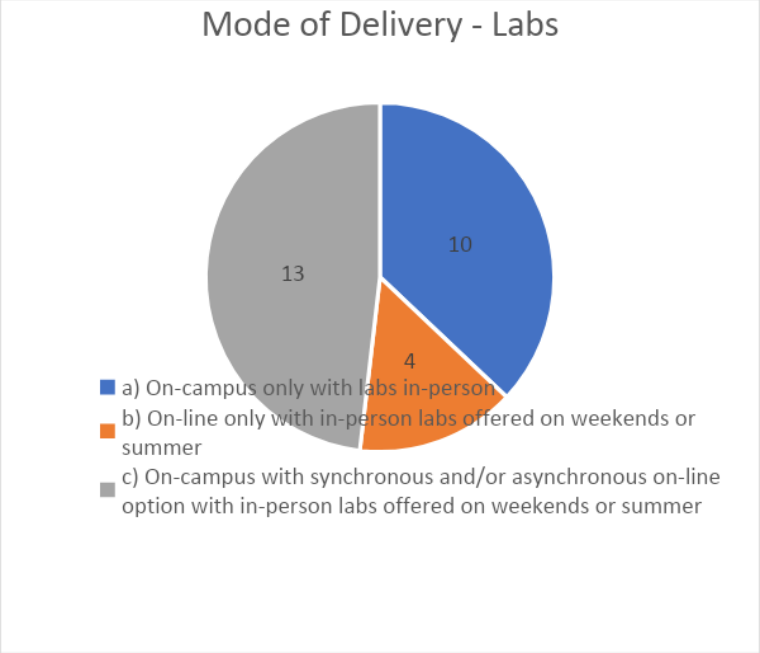

Figure 2. MET current student survey results - course mode options

9. **Curriculum Design**:
Required Manufacturing Engineering Certificate Courses: (3) courses (9) credits total.

Take the (2) courses from this list (6) credits required
MFGE 5000 - Organizational Leadership (3)
MFGE 5100 - Tolerance Analysis with Geometric Dimensioning & Tolerancing (3)

Choose (1) course from this list (3) credits
MFGE 5200 - Industry 4.0 Concepts (3)
MFGE 5300 - Design for Additive Manufacturing (3)

10. **Course Descriptions**:

MFGE 5000 - Organizational Leadership
Team building, ethical decision making, enhanced communication skills, critical thinking, and people skills are discussed. Students learn the practice of leadership as it relates to organizational effectiveness.
Credits: 3.0
Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall Online
Restrictions: Must be enrolled in one of the following Level(s): Graduate

MFGE 5100 - Tolerance Analysis with Geometric Dimensioning & Tolerancing

GD&T is the universal manufacturing language. This course will focus on the ASME Y14.5-2018 standard and cover the concepts of GD&T needed to communicate effectively in the manufacturing sector. Includes: assembly tolerance stack-up, applying and interpreting geometric symbols, datum reference frames, and calculating position and profile tolerance.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Fall Online
Restrictions: Must be enrolled in one of the following Level(s):

MFGE 5200 - Industry 4.0 Concepts
An examination of Industry 4.0 as it relates to manufacturing. Topics include smart factories, cyber physical systems, proactive maintenance, computer simulation, horizontal and vertical integration, and barriers to implementation.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring Online
Restrictions: Must be enrolled in one of the following Level(s): Graduate

MFGE 5300 - Design for Additive Manufacturing
This course looks into the challenges of Additive. Pros and cons of the seven ASTM AM categories are discussed with the view of product purpose: form, fit, function. Effects of build orientation, layer height, particle size, and slicing software has on part integrity are also discussed.
Credits: 3.0
Lec-Rec-Lab: (0-3-0)
Semesters Offered: Spring Online
Restrictions: Must be enrolled in one of the following Level(s): Graduate

11. **Model Schedule**:

Table 3: Sample Course Schedule

Fall semester year 1: 3 credits	**Spring semester year 1: 3 credits**
MFGE 5000 - Organizational Leadership (3)	MFGE 5300 - Design for Additive Manufacturing (3)
Fall semester year 2: 3 credits	
MFGE 5100 - Tolerance Analysis with Geometric Dimensioning & Tolerancing (3)	

12. **Library and other Learning Resources**:

Students will have access to all Library resources, Michigan Tech subscription to digital databases, interlibrary loans, and degree specific subscription-based journals and conference proceedings.

13. **Faculty Resumes**:

The MMET Manufacturing Degree Taskforce Members are the faculty that will teach the certificate courses. Each has five plus years of experience in the manufacturing industry in areas of: operations/facilities management, process engineering, quality management, plant engineering/maintenance supervision, and manufacturing engineering. Faculty have education in leadership studies, organizational leadership and quality, manufacturing operations, mechanical engineering technology, and mechanical engineering.

Table 4. MET Faculty

Faculty Teaching	**Link to Webpage**	**Course(s)**
David Wanless or Nicholas Hendrickson	Link Link	MFGE 5100 - Tolerance Analysis with Geometric Dimensioning & Tolerancing
David Wanless	Link	MFGE 5000 - Organizational Leadership
John Irwin or Scott Wagner	Link Link	MFGE 5300 - Design for Additive Manufacturing
David Labyak	Link	MFGE 5200 - Industry 4.0 Concepts

14. **Equipment**:

No new equipment is required for this certificate.

15. **Program Costs**:

PROGRAM REVENUE	Year 1	Year 2	Year 3	Years 4-n
Enrollment (certificate students)	5	10	15	20
Tuition revenue (certificate students-10 credits/year at $1,285/credit)	$64,250	$128,500	$192,750	$257,000

PROGRAM EXPENSES

The current MMET faculty can teach these courses, and marketing costs can be covered by the MMET department. Additional costs will occur when part time faculty are hired to teach some undergraduate courses. Estimated expenses are 40k per year.

16. **Space**:

No additional space is required because all courses are being offered online.

17. **Policies, Regulations, and Rules**:
    An Accelerated Master's degree option will be available for current Michigan Tech students enrolled in MET, MEEM, or MSE undergraduate programs.

18. **Accreditation Requirements**:
    The certificate will not have professional accreditation. Michigan Tech is accredited by the Higher Learning Commission (HLC). The proposed certificate will meet HLC criteria 3 and 4. The proposed certificate will not seek additional accreditation.

19. **Planned Implementation Date**: Fall 2021

20. **Assessment**:
    Learning objectives of the certificate program will be periodically assessed to continuously improve the curriculum to meet the needs of the learners and to meet accreditation standards. Certificate Learning Objectives: Upon successful completion of this certificate, students will be able to do the following:
    - Manage and/or provide leadership for teams to successfully implement manufacturing processes.
    - Communicate effectively utilizing the fundamental concepts of Geometric Dimensioning and Tolerances (GD&T) necessary in the manufacturing sector.